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Citizens and Technology -- Next Century/Millennium based upon Techno-democracy

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It is significant to discuss the future considering not only term of century but also millennium. Importance of amateur based ethics when developing technologies must be more recognized. Technology must be reconstructed for the people, by the people themselves. Finally technology must be of the people. The author proposes the concept of techno-democracy. From the point of materials development the author established Ken-materials Research Consortium. Typical examples of ken-materials developed by the consortium members will be introduced.
Key words: Ken-materials, techno-democracy, millennium, integration of structural reliability and damage monitoring capability, wisdom index

1. SIGNIFICANCE OF ENTERING NEXT CENTURY/MILLENNIUM

We discuss the future based upon knowledge about the past. Shortly we are entering next millennium. It is significant to discuss the future considering a term of thousand years.

Professional groups like ceramists, alchemists and scientists are recognized in a term of hundred years. The term of hundred years means the birth of professional groups suffixed -ists. Back to the order of 1000 years, we do not see professional ethics and logic there. The Tale of Genji was written by Murasaki-shikibu around 1,000 years ago with amateur ethics.

History of civilization is the history of exploitation. Irrigation caused enrichment of salinity in soil. Rapid economic growth was made possible by rapid consumption of underearth resources. So-called advanced technology made general public alienated. Upon reconciliation of these facts we have to redesign scheme of technology of millennium scale. Important issues of R & D for the next millennium are, therefore, paying attention to environmental impact, people's willingness to technology, recognition of roles of ancestors of ceramics.

2. DIRECTIONS OF TECHNOLOGY

Yanagida proposes that directions of R & D in technology are miniaturization, enlargement of structures, integration and pursuing brevity. Miniaturization of devices saves space, resources and energy. So-called advanced technology has been and still is being developed along this direction. National Project 'Frontier Ceramics' sponsored by STA Japan aims interfaces be well designed and analyzed. Especially non-linear interactions between two different materials including crystal axis orientations are paid much attention to. Non-linear interaction is a source of integration. This is not explained in details due to lack of time and space.

Large scale structures require much energy and resources. Development of technology related to large scale structure, therefore, is very important for saving energy and resources. Maintenance technology is also to be developed to save resources. Key-word to technologies related to large scale structures is simplification and plainness. Yanagida and his group have developed technology where strengthening and damage monitoring capability are fulfilled simultaneously by only one action. Simultaneous fulfillment of more than two requirements by one action leads to concept of integration. Integration makes technology simpler and plainer.

Ken-materials research consortium presided by Yanagida is trying to develop plain technology which is well accepted by general public. Logo-mark is shown in Figure 1. Key words are 7 Chinese characters. 賢, 建, 検, 兼, 健, 倹 and 圏 pronounced as 'ken' in Japan. 賢 denotes 'wisdom' of self-control. 建 is to improve reliability of 'structure'. 検 means primarily to 'sense or monitor' and hence used widely as to enhance functional capability. 兼 is 'integration' of 建 and 検. 健 means 'health or soundness' which people commit themselves willingly for technologies. 倹 is to 'save' energy, resources and to avoid troubles raised from complicated structures. And finally 圏 is

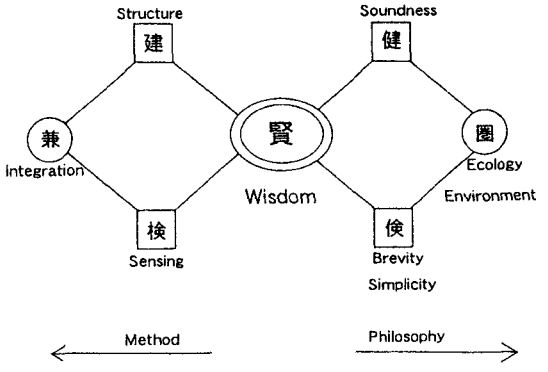

Figure 1. Logo-mark of Ken-materials Research Consortium

'sphere' friendly to environment supported by willing people.

Integration of structural reliability and capability of self-damage monitoring is said to have opened new dimension in R & D of composite materials. Yanagida is recently frequently invited to International Congress related to materials design to present the concept of integration.

Yanagida has proposed a typical case for self-damage monitoring capability and improvement of mechanical performance in CFGFRP, carbon fibers and glass fibers co-reinforced plastics. Shimidzu Co.Ltd. and SOK Co.Ltd collaborated him. If we start with FRP, glass fiber reinforced plastics, an action of mixing with carbon fibers improves elastic modulus and gives rise to capability of damage monitoring by checking change in electric conductance. If we start, on the other hand, with CFRP, carbon fiber reinforced plastics, the action of mixing glass fibers improves stiffness to avoid sudden fracture. CFGFRP has been developed as an alternative of steel bars to reinforce concrete structure to avoid troubles arising from erosion of steel. Yanagida has reached the material from a completely different viewpoint to design strengthening and capability of self-damage monitoring simultaneously. In CFRP we can measure electric conductance. However, the loss of electrical conductance there means fatal fracture of the material. The change in electric conductance before the carbon fibers undergo fracture is very small to detect. Mixture with glass fibers makes possible the material stand further behind the point the carbon fibers suffer fracture. A remarkable change is observed while the material remains still unfractured. The decrease in conductance corresponds the portion of fractured carbon fibers. Life detection is possible by measuring the change. Latent damage after an earthquake of large scale structures such as bridges, highways, buildings can be monitored by measuring the change in conductance including carbon fibers. Damage by invaders through the shell walls of safety chamber can be delayed and monitored by applying the CFGFRP to reinforce the walls. Mixture of carbon fibers with FRP enables not only improvement of mechanical performance of the material but also monitoring of damage. No additional sensors to monitor damage is added here. This is the typical case of integration and integrated material.

Breakdown of carbon fiber usually takes place when the fiber is elongate around 1.0%. In order to check damage due to strain less than 1.0%, change in percolation of carbon powders around the fibers to reinforce ceramic matrix is developed by Ken-materials group of Japan Fine Ceramics Center. Micro cracks of the order of 0.01% in concrete structure is easily detected. This method can be applied to the cases to monitor damage of the structures under high temperature, in deep water or ground, or exposure to strong irradiation.

3. NECESSITY OF SIMPLIFICATION -- TECHNOLOGY SUFFERING FROM SPAGHETTI SYNDROME AND DISTRUSTED BY PEOPLE

The world must aim to prosper through technology but there has been doubt whether it succeeds or fails recently. Environmental destruction which technology has brought about and a distrust of technology itself are getting more serious now. Engineers, who are specialists, makes a blunder again and again as if they had no sense of technology. What the specialists developed is too complicated for people to accept. Some are repulsed by people. It is thought even that technology is developed only by the logic and ethics of the developers and they are self-satisfied, or engineers are insensitive to ordinary people's feeling.

There are many appliances newly produced and hard to handle. It is so stressful to use such appliances. There are a lot of examples of technology not friendly to people: washing clothes by hand because of a new washing machine too complicated to use, flooding a floor of bathroom because of not knowing how to use a high-tech toilet. Although a household appliance or something can be used further with small repairs, repairing it is not easy in Japan today. People have a distrust of such a system and this deepens a gulf between people and technology more and more.

An accident of advanced airplanes enlarges a distrust of advanced technology. The change between automatic control of airplanes and manual control by pilots, what is called override, is a problem. Since the change must be done in an emergency, complicated procedure panics the pilots. To avoid the panic at least, Yanagida thinks that the control system should

be simplified as much as possible.

Yanagida diagnoses the modern technology as suffering from "spaghetti syndrome". The syndrome has five symptoms.

The first is a complicated appearance difficult to understand. Like spaghetti on a dish, it is hard to find where it starts, how it connects and where it ends. Ordinary people simply cannot understand the technology that is too much complicated. Though the people wants to act to reduce a load on the environment, they cannot know how to do because technology is too hard to understand. This is why they feel frustrated.

The second symptom is a method to apply more components to solve problems. This eventually makes technology more complicated. The third is one's values to consider the more complicated the more advanced. Many companies or organizations supporting R&D still omit rational technology from their targets because the technology does not seem to them to be advanced. Though a lack of wisdom causes complicated technology, they do not know it and are even proud of the complexity. To estimate degree of intelligence the speaker proposes an equation.

$$W_I = (\text{Necessary Merits}) / (\text{Numbers of Components})^n$$

where n is greater than 1. We should be proud of a small number of components, the denominator, but sometimes one suffering from spaghetti syndrome boasts of large value of denominator instead.

The forth symptom is paying more attention to trivial things overlooking essential matters. Finally technology becomes degraded by making more complicated. This not only is true for technology itself but also leads to distrust from people. This effect needs to be thought more serious.

4. CONCEPT DESIGN ON A HIGHER LEVEL -- THE CREATIVE WAY TO SIMPLIFY CERAMIC SCIENCE AND TECHNOLOGY

Complicated and difficult science and technology could be understood easily thorough systematizing them in novel concept. Professionals should make an effort for this purpose. Yanagida believes the concept of ken-materials he proposes is an example. Although the effort along the extended lines is necessary in the method for simplification, we must remember that there is a method of conceptualization on a higher level. There are two methods for simplification as follows:

1) to make technology as simple as possible within the same criterion or category.

2) more creative simplification, to systematize phenomena thought difficult and complicated

The pursuit of simplicity and rationality should be the motive force to develop technology. Making technology necessary and as simple as possible promotes the users' understanding, reduces trouble and eases the maintenance.

Simplification is held in high regard not only in the world of technology but also in the literary world. Mr. Fujimoto, Giichi proposes to learn how to write a story from Ihara, Saikaku , which is to shorten "Thirty years having passed since I married my wife" to "Thirty years with my wife"(lectures by Giichi Fujimoto on NHK ETV, Jan.-Mar. 1999). Shakespeare says "Brevity is the soul of wit" (Hamlet 2,2,90).

5. THE NEW TREND IN CERAMICS -- PAYING ATTENTION TO ENVIRONMENTAL IMPACT

One of the most important issues of R & D of ceramics and other materials is paying attention to environmental impact. The relation between ceramics and the environment is of great significance. There are various relations, such as environmental impact during fabrication of ceramics, environmental risk management upon ceramics, contributions of ceramic materials to environmental issues, collaborations with general public upon environmental issues and environmental issues during treatment (including recycling) of ceramics. The relation between ceramics and the environment is adopted as an important topic at PACRIM in Hawaii in 2001.

The most important issue was still to get higher performance or to add higher value about ten years ago. Ceramics, structural ceramics in particular, has capabilities of resisting heat and corrosion. It was expected too much and boomed as materials for engine parts of automobiles or tools, and then the boom cooled down because of high cost of fabrication, lack of reliability and so on. Recently structural ceramics has been booming again as the environmental issues have been seriously considered. Practical applications of structural ceramics steadily have appeared in some areas. Coating metal parts with ceramics or composing parts themselves of ceramics has been successful in order to improve the efficiency of electric power generation, that is to save energy. The ceramics which has high durability and heat-resistivity is already used in the process of steel manufacture. More attention is paid now to saving energy during fabrication of ceramics and during use of the products and utilizing industrial waste to save resources. One of the examples is soil ceramics mentioned above.

Diamond and graphite has been well-known carbon and new carbon materials, such as fullerenes and carbon nanotube were recently found. It is

expected that another new carbon material might be discovered and novel properties or functions may be developed. Frontier Carbon Project, a national project practically started in 1999 to intensively invest money and hands in R & D of the new carbon materials. The material which is chemically simple and has the variety of properties is researched in the project. This is a good example of material research for the Next Millennium.

The materials which can become ceramics through heating are called "precursor". For example, silicon organic compounds are researched and developed to get silicon carbide or silicon nitride through heat treatment. Since precursors are easy to shape, it is possible to shape precursors and then heat them to make them ceramics. In particular, silicon oxide ceramics can be made in designed shape of the precursor which can be silicon nitride. The precursor is heated and oxidized in the air and the volume increases with the oxidation. This helps get the ceramics which is dense or has controlled density. This method is applied to form insulating substrates with precise and complicated shape on integrated circuits.

6. TECHNO-DEMOCRACY AND AN NGO, PORT FOR TECHNO-DEMOCRACY

The strategy to make the relation between technology and the people better is to make technology as simple as possible. Also to enjoy the fruit of technology with the public, Yanagida established an NGO, Port for Techno-democracy on December 21, the winter solstice, 1996. The aim is technology of the people, by the people, for the people.

What the organization does is as follows:

1) Studying to develop rational technology
2) Selecting and praising rational technology
3) Researching and developing rational technology
4) Supporting R & D of rational technology
5) other necessary action to promote techno-democracy.

The first rational technology was selected on the winter solstice in 1998 and soil ceramics of INAX and Co., Ltd. and "Bio-coal" of Hokkaido Industrial Research Institute were praised.

Researchers or engineers would be excited for technology friendly to both people and the environment. Looking at the face of the person who is lively makes us happy. If researchers and companies act openly and happily, the people will not be alienated from technology any more. Steady communication with the people improves the relation between technology and the people. To communicate with the people, it is necessary to make technology as simple as possible. Law would not accept the technology developed without communication with the people in the near future. The technology or companies refusing communication would be boycotted. Isn't this the global standard?

Yanagida wants to gather the cases of being troubled with too complicated technology and to offer them to the developers or companies as action of the NGO, Port for Techno-democracy. He also wants to show what technology should be developed for the next millennium by praising technology for the rationality and simplicity.

Yanagida also wants to find the technology having spoiled technology, that is, the technology which developed like self-multiplying and went the wrong way, as an inside problem of technology. The organization aims to construct virtuous technology and get the system ready for it.

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